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IS 14331 (1995): Steels for high temperature bolting applications [MTD 16: Alloy Steels and Forgings]

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Indian Standard

STEELS FOR HIGH TEMPERATURE BOLTING APPLICATIONS — SPECIFICATION

ICS 77·140·10; 21·060·10

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

December 1995 **Price Group 3**

Alloy Steel and Special Steels Sectional Committee, MTD 16

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Alloy Steel and Special Steels Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard has been prepared with a view to guide the industry for selection of proper steel for fasteners for high temperature bolting applications.

In the preparation of this standard, assistance has been derived from following standards:

> DIN 17240 Heat resisting and highly heat resisting materials for bolts and nuts; Quality specification. Deutsches Institut Für Normung.
>
> ASTM-A193-90 Specification for alloy steel and stainless steel bolting material for high temperature service. American Society for Testing and Materials.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard
STEELS FOR HIGH TEMPERATURE BOLTING APPLICATIONS — SPECIFICATION

1 SCOPE

This standard covers the steels for fasteners for applications at temperature above 300°C, up to the maximum service temperature given in Table 1 which go up to 650°C.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
228	Method for chemical analysis of steels (issued in various parts)
1570 (Part 4) : 1988	Schedules for wrought steels : Part 4 Alloy steels (alloy constructional and spring steels) with specified chemical composition and related mechanical properties (*first revision*)
1598 : 1977	Method for Izod impact test of metals (*first revision*)
1608 : 1995	Mechanical testing of metals — Tensile testing (*second revision*)
3407 (Part 1) : 1983	Method for creep testing of steel at elevated temperature: Part 1 Tensile creep testing (*first revision*)
3407 (Part 2) : 1983	Method for creep testing of steel at elevated temperature: Part 2 Tensile creep stress rupture testing (*first revision*)
3664 : 1981	Code of practice for ultrasonic pulse echo testing contact and immersion methods (*first revision*)
4163 : 1982	Method for determination of inclusion content in steel by microscopic method (*first revision*)
4748 : 1988	Method for estimating average grain size of metals
8910 : 1978	General technical delivery requirements for steel and steel products
13015 : 1991	Macroetch testing, inspection and rating of steel products

3 SUPPLY OF MATERIAL

General requirements relating to the supply of material shall conform to IS 8910 : 1978.

4 CHEMICAL COMPOSITION

4.1 The ladle analysis of the steels, when carried out either by the method specified in the relevant part of IS 228 or any other established instrumental/chemical method shall be as given in Table 1. In case of dispute, the procedure given in the relevant part of IS 228 shall be the referee method.

4.2 Product Analysis

The check analysis shall be carried out on the finished product. The permissible variation, in the case of such check analysis for the limit specified in Table 1, shall be as given in Table 2.

4.3 Elements not specified in Table 1 shall not be added to the steels except where agreed to, other than for the purpose of finishing the heat, and shall not exceed the following limits:

Constituent	*Percent, Max*
Chromium	0·25
Nickel	0·25
Copper	0·35
Vanadium	0·05
Molybdenum	0·06

5 METHOD OF MANUFACTURE

5.1 Unless otherwise specified in the order, the process used in making of steel shall be left to the discretion of the manufacturer. However, the manufacturing process shall be intimated to the customer, if he so desires.

5.2 Sufficient discard shall be made from each ingot to ensure freedom from piping, harmful porosity, undue segregation and other defects in the bars, as supplied.

5.3 The reduction from a cast ingot to the final bar size shall be minimum four times and for continuously cast billet to the final bar size minimum six times.

6 MECHANICAL PROPERTIES

6.1 When tested in accordance with IS 1608 : 1995, the test pieces shall show room temperature mechanical properties as in Table 3.

6.2 When tested in accordance with IS 1598 : 1977, the test piece shall show room temperature impact properties as in Table 3.

7 MACROETCH TEST

The product shall be tested for internal quality in accordance with IS 13015 : 1991. The acceptance limit shall be agreed upon between the producer and the purchaser.

8 SURFACE CONDITION

8.1 Surface defects like scales, grooves, laps, cracks and surface decarburization shall be within the machining allowance as mutually agreed to between the manufacturer and purchaser. Correcting surface defects by welding is not permitted.

8.2 In case of material meant for forging, harmful surface defect which might open up shall be removed by a suitable method within the dimensional tolerance as agreed to between manufacturer and purchaser.

9 ULTRASONIC TESTS

Each bar shall be tested ultrasonically (*see* IS 3664 : 1981). Ultrasonic test shall be conducted as per IS 3664 : 1981 and the acceptance standard may be mutually agreed upon.

10 ELEVATED TEMPERATURE PROPERTIES

10.1 Hot Tensile Properties

When tested in accordance with IS 1608 : 1995 the minimum 0·2 percent proof stress of various grades of steels shall be as given in Table 4.

10.2 Stress Rupture Properties

When tested in accordance with IS 3407 (Part 1) : 1983 and IS 3407 (Part 2) : 1983, the properties of the given grades are given in Tables 5 to 11 for guidance only.

10.3 Stress Relaxation Properties

The relaxed stress for the given grades of steels are given in Tables 7, 9, 10 and 11 for guidance only.

11 SAMPLING

11.1 For heat treated bars, one tension test shall be made for each diameter of each heat represented in each tempering charge.

11.1.1 Notch bar impact test shall be carried out on the same bar as the tensile specimens taken from.

11.2 Extent of testing for macroetch test and hot tensile properties may be mutually agreed upon.

12 RETESTS

If the results of the mechanical tests of any test lot do not conform to the requirements specified, the manufacturer may reheat-treat such lot not more than twice, in which case two additional tensile tests shall be made from such lot, all of which shall conform to the requirements specified.

13 PACKING AND MARKING

13.1 For bolting materials, including threaded bars, that are furnished bundled and tagged or boxed, the tags and boxes shall carry the grade symbol for the material identification and the manufacturer's identification mark or name.

13.2 BIS Certification Marking

The material may also be marked with the Standard Mark.

13.2.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to the manufacturers or producers may be obtained from the Bureau of Indian Standards.

Table 1 Chemical Requirements (Composition, Percent)

(*Clauses* 1, 4.1, 4.2 *and* 4.3)

Sl No.	Grade	Element, Percent												Recommended Temperature of Application for Continuous Operation Up to °C
		C	Si	Mn	Cr	Mo	V	Ni	Ti	B	N	S	P	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
i)	35C8	0·32- 0·39	0·15- 0·35	0·50- 0·80	—	—	—	—	—	—	—	0·035	0·035	350
ii)	40C8	0·35- 0·45	0·15- 0·35	0·60- 0·90	—	—	—	—	—	—	—	0·035	0·035	425
iii)	24Cr4Mo3	0·20- 0·28	0·15- 0·35	0·50- 0·80	0·90- 1·20	0·20- 0·35	—	—	—	—	—	0·035	0·030	400
iv)	43Cr4Mo2	0·37- 0·49	0·15- 0·35	0·65- 1·10	0·75- 1·20	0·15- 0·25	—	—	—	—	—	0·04	0·035	480
v)	40Cr5Mo6	0·35- 0·45	0·10- 0·35	0·40- 0·70	1·00- 1·50	0·50- 0·70	—	—	—	—	—	0·04	0·04	480
vi)	21Cr5Mo7V3	0·17- 0·25	0·15- 0·35	0·35- 0·85	1·20- 1·50	0·65- 0·80	0·25- 0·35	—	—	—	—	0·035	0·030	540
vii)	40Cr4Mo6V3	0·36- 0·47	0·15- 0·35	0·45- 0·70	0·80- 1·15	0·50- 0·65	0·25- 0·35	—	—	—	—	0·040	0·035	540
viii)	20Cr5Mo10V8TiB	0·17- 0·24	0·35 *Max*	0·50 *Max*	0·90- 1·40	0·80- 1·10	0·70- 1·00	—	0·05- 0·12	0·001- 0·005	—	0·030	0·035	565
ix)	X21Cr12Mo1V3	0·18- 0·24	0·10- 0·50	0·30- 0·80	11·0- 12·5	0·80- 1·20	0·25- 0·35	0·30- 0·80	—	—	—	0·035	0·040	580
x)	X04Cr17Ni12Mo2N	0·08 *Max*	1·00 *Max*	2·00 *Max*	16·0- 18·0	2·0- 3·0	—	10·0- 14·0	—	—	0·10- 0·16	0·030	0·045	800

Table 2 Product Variation in Chemical Analysis

(*Clause* 4.2)

Sl No.	Element	Range	Permissible Check Analysis Variation from Ladle Analysis (%)
(1)	(2)	(3)	(4)
i)	Carbon	0·20 0·20-0·49	± 0·02 ± 0·02
ii)	Silicon	1·00	± 0·05
iii)	Manganese	2·00	± 0·05
iv)	Chromium	1·50 11·00-12·50 16·00-18·00	± 0·05 ± 0·15 ± 0·20
v)	Molybdenum	0·35 0·35-1·20 2·00-3·00	± 0·04 ± 0·05 ± 0·10
vi)	Vanadium	0·35 0·70-1·00	± 0·03 ± 0·05
vii)	Nickel	0·80 10·00-14·00	± 0·03 ± 0·15
viii)	Titanium	0·12	± 0·010
ix)	Boron	0·005	± 0·000 3
x)	Nitrogen	0·16	± 0·010
xi)	Sulphur	0·045	+ 0·005
xii)	Phosphorus	0·045	+ 0·005

Table 3 Room Temperature Mechanical Properties

(*Clauses* 6.1 *and* 6.2)

Sl No.	Grade	Ruling Section mm	Mechanical Properties				
			0·2% Proof Strength MPa (*Min*)	U.T.S. MPa	% Elongation $L_o = 5{\cdot}65\sqrt{So}$ *Min*	% Reduction in Area (% *Min*)	Impact Strength ISO ·V· Notch J-*Min*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	35C8	Up to & Incl 60	280	500-850	22	45	55
		Over 60-160	280	500-650	22	45	39
ii)	40C8	Up to & Incl 30	410	660-800	16	35	—
		Over 30-100	375	600-750	17	40	—
iii)	24Cr4Mo3	Up to & Incl 100	440	600-750	18	60	118
		Over 100-160	420	600-750	18	60	102
iv)	43Cr4Mo2	Up to & Incl 65	720	860 *Min*	13	50	—
		Over 65-100	655	790 *Min*	13	50	—
		Over 100-180	515	690 *Min*	14	50	—
v)	40Cr5Mo6	Up to & Incl 65	695	845 *Min*	14	—	21
		Over 65-100	665	845 *Min*	14	—	16
		Over 100-200	640	845 *Min*	14	—	10·5
vi)	21Cr5Mo7V3	Up to & Incl 250	550	700-850	16	60	63
vii)	40Cr4Mo6V3	Up to & Incl 65	720	860 *Min*	15	50	—
		Over 65-100	655	760 *Min*	14	45	47
		Over 100-180	585	690 *Min*	13	45	—
viii)	20Cr5Mo10V8TiB	Up to & Incl 200	650-800	735 *Min*	15	45	22
		Over 200-300	490-640	600 *Min*	16	50	30
ix)	X21Cr12Mo1V3	Up to & Incl 250	600 *Min*	800-950	14	40	27
			700 *Min*	900-1 050	11	35	20
x)	X04Cr17Ni12Mo2N		205 *Min*	515 *Min*	27	50	—

Table 4 Hot Tensile Properties

(*Clause* 10.1)

Sl No.	Grade	Ruling Section mm	0·2 % Proof Strength MPa at						
			300°C	350°C	400°C	450°C	500°C	550°C	600°C
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	35C8	Up to 160	186	167	147	—	—	—	—
ii)	40C8	Up to 160	190	170	150	—	—	—	—
iii)	24Cr4Mo3	Up to 100	363	333	304	275	235	—	—
		Over 100-160	344	324	294	265	226	—	—
iv)	43Cr4Mo2	Up to 100	360	330	300	275	235	—	—
v)	40Cr5Mo6	—	700	—	650	600	540	430	—
vi)	21Cr5Mo7V3	Up to 250	460	441	412	372	334	275	—
vii)	40Cr4Mo6V3	Up to 100	598	578	540	500	460	403	—
viii)	20Cr5Mo10V8TiB	Over 200-300	—	—	—	—	580	540	—
ix)	X21Cr12Mo1V3	Up to 250	480	452	423	382	344	284	206
			550	515	485	442	392	329	250
x)	X04Cr17Ni12Mo2N	—	145	—	145	—	130	—	124

Table 5 Stress Rupture Properties for 35C8

(*Clause* 10.2)

Temperature °C	Stress Rupture Strength, MPa	
	at 10 000 h	at 100 000 h
(1)	(2)	(3)
350	246	218
400	187	135
450	100	69

Table 6 Stress Rupture Properties for 40C8

(*Clause* 10.2)

Temperature °C	Stress Rupture Strength, MPa	
	at 10 000 h	at 100 000 h
(1)	(2)	(3)
350	270	201
400	190	140
450	100	70

Table 7 Stress Rupture and Relaxation Properties for 40Cr5Mo6

(*Clauses* 10.2 *and* 10.3)

Temperature °C	Stress Rupture Strength, MPa		Mean 30 000 h Relaxed Stress at 0·15% Initial Strain
	at 10 000 h	at 100 000 h	
(1)	(2)	(3)	(4)
425	—	—	135
450	440	—	96
475	—	—	49
500	230	—	—

Table 8 Stress Rupture Properties for 24Cr4Mo3

(*Clause* 10.2)

Temperature °C	Stress Rupture Strength, MPa	
	at 10 000 h	at 100 000 h
(1)	(2)	(3)
420	387	308
450	311	226
500	176	118

Table 9 Stress Rupture and Relaxation Properties for 21Cr5Mo7V3 and 40Cr4Mo6V3

(*Clauses* 10.2 *and* 10.3)

Temperature °C	Stress Rupture Strength MPa		Mean Relaxed Stress at 0·2% Initial Strain, MPa	
	at 10 000 h	at 100 000 h	After 10 000 h	After 30 000 h
(1)	(2)	(3)	(4)	(5)
450	405	328	186	154
500	271	188	81	56
540	189	111	33	18

Table 10 Stress Rupture and Relaxation Properties for 20Cr5Mo10V8TiB

(*Clauses* 10.2 *and* 10.3)

Temperature °C	Stress Rupture, MPa		Relaxed Stress, MPa	
	at 10 000 h	at 100 000 h	After 5 000 h	After 10 000 h
(1)	(2)	(3)	(4)	(5)
450	470	440	—	—
500	380	325	178	170
565	285	245	125	100

Table 11 Stress Rupture Properties for X21Cr12Mo1V3

(*Clauses* 10.2 *and* 10.3)

Temperature °C	Hardened and Tempered to UTS of 800-950 MPa		Hardened and Tempered to UTS of 900-1 050 MPa		Mean Relaxed Stress at 0·2% Initial Strain MPa	
	Stress Rupture Strength, MPa		Stress Rupture Strength, MPa		After 10 000 h	After 30 000 h
	at 10 000 h	at 100 000 h	at 10 000 h	at 100 000 h		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
450	480	432	516	445	173	155
500	338	275	368	288	103	85
550	211	137	222	144	51	38
580	143	83	148	84	32	20

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